Eur J Transl Myol 33 (3) 11855, 2023 doi: 10.4081/ejtm.2023.11855

Comments on: Electromyographic signature of isometric squat in the highest refuge in Europe

Danilo Bondi (1), Vittore Verratti (2)

(1) Department of Neuroscience, Imaging and Clinical Sciences, University "G. d'Annunzio" of Chieti - Pescara, Chieti, Italy; (2) Department of Psychological, Health and Territorial Sciences, University "G. d'Annunzio" of Chieti-Pescara, Chieti, Italy.

Abstract

We read the comment by Šarabon and Sašek (Eur J Transl Myol 11846, 2023 doi: 10.4081/ejtm.2023.11846) on our study on the electromyographic results during squat at high-altitude. Their highlighting of the factors that may have biased our results is commendable, despite they criticized our work as if it were a controlled laboratory study. We considered the limitations and argued our interpretation with caution. We found no changes in median frequency, frequency's slope and conduction velocity of EMG signals at high altitude, and a slight decrease of root mean square. We argued that our results may have been due to a preventative mechanism that compensates for relatively greater effort during a fatiguing strength test involving large muscle masses, or to cumulative exertional stress on the muscles. The authors of the comment themselves somehow agree with these interpretations. Guidelines for collecting, reporting and interpreting data from EMG to obtain original information on the neuromuscular system should be integrated with the effort to maintain as much as possible those field conditions that offer unique opportunities.

Key Words: hypoxia; HD-sEMG; high-altitude; observational study.

Eur J Transl Myol 33 (3) 11855, 2023 doi: 10.4081/ejtm.2023.11855

Muscle activity, neuromuscular system control strategies and fatigue manifestation can be studied through surface electromyography (sEMG). The recent development of high-density configuration (hd-sEMG) further expanded the applicability, allowing to estimate single motor units (MU) contributions. However, hd-sEMG recording and data analysis for estimating muscle behavior have not yet been sufficiently implemented in field studies.

We came across the letter of Šarabon and Sašek[1], who criticized our recent study[2]. In particular, authors were surprised about some unchanged features of EMG signals at high-altitude, attributing these results to confounding factors arising from non-standard procedures and EMG measurement methodology rather than to the combined stressors of trekking and hypoxia. We were aware that accurately standardising hip, knee and ankle angles, along with normalising signals to the values obtained during maximal voluntary contraction and using a standardised configuration of all body segments is critical to avoid biases. However, it is not appropriate to criticize a field study as if it were a controlled laboratory study. Real-world conditions pose a plethora of confounding factors that are difficult to control for even in the most accurate setting, which is not what the authors would find in tourist mountain lodges (readers can refer to Figure 1).

To give an example of their out-of-context criticism authors stated that "pace and duration of the trek were not uniform" and that "future studies aiming to compare acute changes in neuromuscular function during squat after high-altitude trekking should use exercise interventions that are balanced in pace and duration". Even if the pace and duration were identical, peripheral and central fatigue, along with possible symptoms and harsh weather conditions, would be confounding factors inherently present during extreme physiology field studies.

Our approach to EMG at high-altitude followed the need to bring aspects of the real-world physiological response under rigorously controlled laboratory scrutiny. In particular, we aimed to provide pilot evidence from ecological analyses to optimize further research and applications of EMG. In epidemiology, ecologic analyses focus on data aggregated over groups to make inferences about etiologic hypotheses or impact of intervention. Our ecological approach, also used in other disciplines, refers

Fig 1. *Procedural setting: the left panel shows participant who was trying the task while the operator was controlling the quality of the signal; right panel shows the placement of the electrode matrix, under which the skin had been shaved and cleaned*

to the design of a field study where investigators do not modify contextual factors following the priciples of dynamic organism-environment relations, affordances, developmental changes, socio-cultural strategies, extra-individual behavioural structures, and variation [3]. The shared issue between these two approaches on what ecological means is that the possibility to make inference is limited due to problems of confounders control.

We want to clarify that in extreme-physiology studies scholars cannot use field conditions as excuses for conducting confusing and scientifically inappropriate studies, we did not nor do we want to do it hereinto. Our concern as scientists is to ensure that our research offers significant and unbiased contributions to the scientific community. The purpose of our study, clearly stated, was to test the changes, if any, in muscle activity as computed from hd-sEMG recording under altitude hypoxia, by using an ecological study design and a common whole-body exercise that involved massively those muscles involved in trekking, with no special equipment required. Šarabon and Sašek will undoubtedly appreciate the complexities of conducting experiments in high-altitude environments. Despite these challenges, our team ensured that conditions, particularly temperature and daytime of analyses, remained as constant as possible at both low and high altitude. Prior to measurements, all participants prepared theirselves to ensure that muscle activities were consistent and not influenced by sudden environmental shifts. We visually observed joint angles during the tasks, accurately prepared the skin, placed the electrode matrix, and controlled the quality of EMG signals. We honestly admitted that signals did not allow adequate estimation of single MU contributions. Moreover, we had to navigate through noisy signals to set adequate procedures for obtaining valid RMS, frequency and MFCV values. We affirmed several limitations that possibly biased our results, which can be non-exhaustively listed as 1) the lack of normalization of sEMG amplitude, because context factors did not allow us to perform a maximal test in both lodges controlling for all contextual factors; 2) the free-standing isometric squat that limited the control of position resulting possibly in compensations; 3) the limited sample size; 4) the the difference in PA type and level across participants.

Therefore, we used caution when interpreting our results. Šarabon and Sašek stated that the signatures we observed in EMG singals "could simply be the result of compensations in squatting at low or high altitude" and that "it is possible that these manifested more strongly at high altitude due to increased fatigue following the trek". This interpretation did not surprise us, because is what we already discussed in our manuscript, arguing that the unexpected slight decrease in RMS may be explained by a preventive mechanism compensating for a relatively greater effort during a fatiguing strength test involving large muscle masses, or by a cumulative exertional stress on muscles.

All in all, despite the issues, we concluded that hypoxia *per se* may have minimal, if any, effects on the myoelectric activity of large masses during exercise, in line with contrasting results existing in literature. We ourselves are using this pilot evidence and the pittfalls encountered to optimize our studies involving EMG. Further studies would merge the guidelines for collecting, reporting, and interpreting data from hd-

sEMG[4] - which allow to obtain valid and original insights about the neuromuscular system - with the effort in maintaining, as possible, those field conditions which offer irreplaceable opportunities to increase knowledge of the physiological response in extreme environments.

List of acronyms

EMG – electromyography
MU – motor unit
RMS – root mean square
MFCV – muscle fiber conduction velocity
PA – physical activity

Contributions of Authors

DB, ideas, writing, approval; VV, supervision, approval. The authors read and approved the final edited manuscript.

Acknowledgments None.

Funding

None.

Conflict of Interest None.

Ethical Publication Statement

We confirm that we have read the Journal's position on issues involved in ethical publication and affirm that this report is consistent with those guidelines.

Corresponding Author

dr. Danilo Bondi,
Department of Neuroscience, Imaging and Clinical Sciences, University "G. d'Annunzio" of Chieti - Pescara, Via dei Vestini, 31 Chieti, Italy.
ORCID iD: 0000-0003-1911-3606
Email: danilo.bondi@unich.it

E-mail and ORCID iD of co-author

Vittore Verratti: vittore.verratti@unich.it
ORCID iD: 0000-0001-8343-9024

References

1. Šarabon N. and Sašek M. Comments on Electromyographic signature of isometric squat in the highest refuge in Europe by Rua et al. (Eur J Transl Myol. 33 (3) 11637, 2023 doi: 10.4081/ejtm.2023.11637): Standardisation of measurement protocols is crucial to obtain valid electromyographic signal parameters. Eur J Transl Myol 11846, 2023 doi: 10.4081/ejtm.2023.11846
2. Rua R, Bondi D, Santangelo C, Pignatelli P, Pietrangelo T, Fulle S, Fanelli V, Verratti V. Electromyographic signature of isometric squat in the highest refuge in Europe. Eur J Transl Myol. 2023 Sep 12. doi: 10.4081/ejtm.2023.11637. Epub ahead of print. PMID: 37700736.
3. Heft H. An Ecological Approach to Psychology. Review of General Psychology. SAGE Publications Inc; 2013 Jun 1;17(2):162–167.
4. Gallina A, Disselhorst-Klug C, Farina D, Merletti R, Besomi M, Holobar A, Enoka RM, Hug F, Falla D, Søgaard K, McGill K, Clancy EA, Carson RG, van Dieën JH, Gandevia S, Lowery M, Besier T, Kiernan MC, Rothwell JC, Tucker K, Hodges PW. Consensus for experimental design in electromyography (CEDE) project: High-density surface electromyography matrix. Journal of Electromyography and Kinesiology. 2022 Jun 1;64:102656. PMID: 35344841

Disclaimer

Submission: September 21, 2023
Accepted for publication: September 21, 2023